

# PHILOSOPHICAL TRANSACTIONS.

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- I. *Experiments to ascertain the ratio of the magnetic forces acting on a needle suspended horizontally, in Paris and in London.* By Captain EDWARD SABINE, of the Royal Artillery, Secretary of the Royal Society.

Read June 21, 1827.

THE magnetic needles employed in these experiments were cylinders of 0,16 inch diameter, and 2,4 inches in length, pointed at the ends: they were suspended by a single silk fibre of rather more than five inches in length. The box in which they were inclosed, as a protection from the weather, was of wood, having at the bottom a graduated circle in ivory, rather exceeding in diameter the length of the needles, and over the centre of which the silk fibre was suspended. The bottom of the box being rendered horizontal by means of foot screws, and shown to be so by an unattached spirit level, the zeros of the circle were placed in the direction of the magnetic meridian, and a needle was suspended in a horizontal position. Another needle was then employed to draw it 50 or 60 degrees from its natural direction; on the removal of which, the suspended needle resumed its direction in the ordinary process of vibration. The registry of the vibrations was commenced when the arc had diminished to  $30^{\circ}$ , and continued until it was reduced to below  $5^{\circ}$ : the method of registering the vibration will be best understood by a reference to the Tables at the close, and is too simple to require further explanation. The number of vibrations made by each needle between the arcs of  $30^{\circ}$  and  $5^{\circ}$  was usually from 300 to 400; and the time in which these were performed varied, in the different needles, from 12 to 16 minutes: the mean time of performing 100 vibrations between the specified arcs is the result deduced for each experiment.

Four of the needles, Nos. IV, VIII, X, and XI, with an apparatus in duplicate, were sent to me in the summer of 1826 by Professor HANSTEEN of Christiania, to be employed in obtaining the comparative magnetic intensity in different parts of Great Britain. Shortly after their arrival, an opportunity occurred of sending two of the needles, Nos. IV and XI, with an apparatus, to Captain BASIL HALL, in Edinburgh; by whom, assisted by Lieut. ROBERT CRAIGIE, of the Royal Navy, the experiments numbered 12 to 16 in the subjoined tables were made, in February 1827; and the needles returned, so as to be included in the comparative experiments between Paris and London.

The two remaining needles, marked A and B, making six in all, were made, at my request, by Mr. DOLLOND, in the autumn of 1826, of the same size and form as those sent me by Professor HANSTEEN.

On the 3rd of December 1826, being about seven weeks before I expected to leave England for Paris, I made the experiments 1 to 4, with needles A and B, VIII and X, in the garden of the Horticultural Society at Chiswick; and after an interval of six weeks, repeated, with the same needles, at Shernfold Park near Tunbridge Wells, on the 15th of January, the experiments 5 to 8, to ascertain that their magnetism had sustained no change. On the 30th of January, fifteen days only after this second trial, three of the needles, No. VIII, A, and B, (No. X having been accidentally mislaid on that day,) were employed in the garden of the Royal Observatory at Paris, in the experiments numbered 9 to 11; and on the 14th of March, Nos. X and XI (which last had been returned by Captain HALL from Edinburgh), and the needles A and B repeated, were employed in the experiments numbered 17 to 20; in which observations I had the pleasure of being assisted by Mr. WILLIAM RITCHIE, rector of Tain Academy in Scotland.

An opportunity occurring, Nos. VIII, X, and XI, were sent to England early in April, and the experiments numbered 21 to 24 made with those three needles and, with No. IV (sent by Captain HALL to London, but which had not been forwarded to me in Paris), in the garden of the Horticultural Society at Chiswick, on the 23rd of April, by Captain CHAPMAN of the Royal Artillery, who kindly undertook this trouble at my request; and having done so, returned them again to me at Paris.

By Professor HANSTEEN's recommendation, the four needles which he had

sent me were kept at all times separate from each other ; the two which Mr. DOLLOND made had been on the contrary kept together in a small ivory case ; the needles being placed parallel, but not touching, the north pole of the one being opposed to the south pole of the other, but not connected. Being desirous of ascertaining the effect which separation might have on the magnetism of these needles (A and B), they were removed from each other after the experiments of the 14th of March, and kept apart until the 30th of April ; when they were again tried in the garden of the Observatory at Paris, in experiments 25 and 26, and their time of vibration was found the same as before. Nos. VIII and XI, which had arrived from Captain CHAPMAN, were tried on the same day, Experiments 27 and 28, and Nos. IV and X, which arrived a few days after, on the 10th of May, in the experiments 29 and 30. Finally, on my return to England in June, the needles were again taken to the garden at Chiswick, and the experiments 31 to 34 made on the 11th of June.

The place of observation in the garden at Chiswick was near the middle of the Arboretum ; and in the garden of the Observatory at Paris, in the Cabinet of M. ARAGO, specially constructed for magnetic observations, which he kindly permitted me to occupy for the purpose.

The Tables at the close contain the full details of the temperatures and the hours of the day at which the several experiments were made. It will be seen that the variations of temperature included at each station were very considerable ; but care was taken that the mean temperature of the several experiments with each needle should, in most cases at least, approach the same amount at London and at Paris :

With Needle IV	the mean temp. at London was 54,5	and at Paris 62
With Needle VIII	. . . . . 50	. . . . . 52,5
With Needle X	. . . . . 40,5	. . . . . 59
With Needle XI	. . . . . 54,5	. . . . . 66,5
With Needle A	. . . . . 55	. . . . . 54
With Needle B	. . . . . 54,5	. . . . . 53

Still the preponderance of high temperatures was at Paris ; and it is expedient therefore to reduce the several results to a nearer accord with what they would have been, had they been all made at the same temperature. I avail myself for this purpose of a formula for the reduction of different tem-

peratures, which Professor HANSTEEN has derived from experiments made with a cylinder precisely similar in all respects to those which he sent to me. Supposing the time of  $n$  vibrations in the temperature  $t$  to be  $T$  seconds, and in the temperature  $t'$  to be  $T'$  seconds,  $T = T' [1 - 0,000165 (t' - t)]$ , the temperature being expressed in degrees of Fahrenheit. It is possible that this reduction may not be strictly correct for all cylinders of the same shape and make as that from whence it was originally derived; but it may at least be confidently presumed, that the results obtained by such cylinders being corrected by it, will more nearly approach a strict relation to each other, than when no attempt is made to counteract the effect of differences of temperature: and that, viewing the small ultimate amount to be compensated in the present case, this formula may be considered as being quite sufficient for the purpose.

The following Table presents in one view the results obtained with each needle at the different stations at which they were tried.

Needle.	LONDON.					PARIS.				
	Date.	Therm.	Time of Vibration.	Reduction to 40°.	Corrected Time of Vibration.	Date.	Therm.	Time of Vibration.	Reduction to 40°.	Corrected Time of Vibration.
IV {	Apr. 23, 1827, 1 P.M.	40	341,69	0,00	341,69	May 10, 1827, 5½ P.M.	62	331,12	-1,20	329,92
	June 11, 1827, 2½ P.M.	69	343,21	-1,64	341,57					
	Mean.....	...	.....	.....	341,63	Mean.....	...	.....	.....	329,92
VIII {	Dec. 3, 1826, 2½ P.M.	41	275,85	-0,05	275,80	Jan. 30, 1827, 11½ A.M.	28	267,22	+0,53	267,75
	Apr. 23, 1827, 2 P.M.	40	276,44	0,00	276,44	Apr. 30, 1827, 5½ P.M.	77	268,76	-1,64	267,12
	June 4, 1827, 1½ P.M.	69	278,02	-1,33	276,69					
	Mean.....	...	.....	.....	276,31	Mean.....	...	.....	.....	267,435
X {	Dec. 3, 1826, 2 P.M.	41	329,63	-0,05	329,58	Mar. 14, 1827, 1½ P.M.	56	319,17	-0,84	318,33
	Apr. 23, 1827, 2½ P.M.	40	330,86	0,00	330,86	May 10, 1827, 5 P.M.	62	320,38	-1,16	319,22
	Mean.....	...	.....	.....	330,22	Mean.....	...	.....	.....	318,775
XI {	Apr. 23, 1827, 3 P.M.	40	313,98	0,00	313,98	Mar. 14, 1827, 2½ P.M.	56	304,13	-0,80	303,33
	June 11, 1827, 3½ P.M.	69	315,37	-1,53	313,84	Apr. 30, 1827, 5 P.M.	77	304,73	-1,86	302,87
	Mean.....	...	.....	.....	313,91	Mean.....	...	.....	.....	303,10
A {	Dec. 3, 1826, 3½ P.M.	41	247,03	-0,05	246,98	Jan. 30, 1827, Noon.	28	238,95	+0,48	239,43
	June 11, 1827, 4 P.M.	69	250,07	-1,20	248,87	Mar. 14, 1827, 2½ P.M.	56	240,73	-0,63	240,10
	Mean.....	...	.....	.....	247,925	Apr. 30, 1827, 3½ P.M.	77	241,20	-1,47	239,73
						Mean.....	...	.....	.....	239,573
B {	Dec. 3, 1826, 3 P.M.	41	345,94	-0,05	345,89	Jan. 30, 1827, 1 P.M.	28	331,85	+0,66	332,51
	June 15, 1827, 3½ P.M.	68	349,16	-1,59	347,57	Mar. 14, 1827, 3 P.M.	56	337,21	-0,88	336,33
	Mean.....	...	.....	.....	346,73	Apr. 30, 1827, 3 P.M.	77	338,01	-2,06	335,95
						Mean.....	...	.....	.....	334,93

From the results in the preceding Table it appears that when the horizontal intensity in London is taken as unity, the same intensity in Paris is shown by the several cylinders to be as follows :

By Needle	IV	= 1,0732
By Needle	VIII	= 1,0675
By Needle	X	= 1,0726
By Needle	XI	= 1,0723
By Needle	A	= 1,0709
By Needle	B	= 1,0717

Mean . . . . 1,07137 or 1,0714.

From the very careful observations which are regularly made on the dip of the needle at the Royal Observatory at Paris, the mean dip corresponding to the period when these experiments were made is known to have been  $67^{\circ} 58'$ . In assuming the dip at the same period at London to have been  $69^{\circ} 45'$ , which is allowing a diminution of  $3'$  per annum since it was observed in 1821 to be  $70^{\circ} 04'$ , (Phil. Trans. for 1822, Art. I.) we cannot fail to be sufficiently near the truth for the present purpose. The horizontal intensity at Paris being then as 1,0714, to unity at London, it results that the absolute intensity of terrestrial magnetism was greater at London than at Paris at the period of these experiments by about eleven parts in a thousand.

The experiments of Captain HALL and Lieut. CRAIGIE at Edinburgh with Nos. IV and XI give the following results :

Needle.	EDINBURGH. <sup>s</sup>					LONDON.	
	Date.	Temp.	Time of Vibration.	Reduction to $40^{\circ}$ .	Corrected Time of Vib <sup>n</sup> .		Corrected Time of Vib <sup>n</sup> .
No. IV	Feb. 15, 1827.	32 <sup>o</sup>	350,47 <sup>s</sup>	+ 0,46 <sup>s</sup>	350,93 <sup>s</sup>	Vibrations in London at $40^{\circ}$ page 4.	341,63 <sup>s</sup>
No. XI	Feb. 15, 1827.	32	321,07	+ 0,43	321,50	Vibrations in London at $40^{\circ}$ page 4.	313,91

Whence the horizontal intensity at Edinburgh, when the same intensity at London is taken as unity, is by

$$\left. \begin{array}{l} \text{No. IV} = 0,9477 \\ \text{No. XI} = 0,9534 \end{array} \right\} \text{ And by a mean of the two Needles, } 0,9505.$$

In the Horticultural Society's Garden at Chiswick, near London :  
December 3d, 1826.

Observer, Captain SABINE. Therm. 41°. Chron. MOLYNEUX 407. Rate, nearly Mean Time.

EXP. 1. NEEDLE VIII. Hour 2½ P.M.					EXP. 2. NEEDLE X. Hour 2 P.M.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	260 Vib <sup>ns</sup> . in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	200 Vib <sup>ns</sup> . in
0	<sup>m</sup> <sup>s</sup> 40 29,6	260	<sup>m</sup> <sup>s</sup> 52 27,6	<sup>m</sup> <sup>s</sup> 11 58	0	<sup>m</sup> <sup>s</sup> 8 56	200	<sup>m</sup> <sup>s</sup> 19 56,4	<sup>m</sup> <sup>s</sup> 11 00,4
10	40 57,6	270	52 55,2	11 57,6	10	9 29,2	210	20 29,2	11 00
20	41 25,2	280	53 22,8	11 57,6	20	10 02,8	220	21 02	10 59,2
30	41 53,2	290	53 50,4	11 57,2	30	10 35,6	230	21 34,8	10 59,2
40	42 20,8	300	54 17,6	11 56,8	40	11 08,8	240	22 08	10 59,2
50	42 48,8	310	54 45,6	11 56,8	50	11 42,4	250	22 40,8	10 58,4
60	43 16,4	320	55 12,8	11 56,4	60	12 15,2	260	23 13,6	10 58,4
80	44 12	Mean ....11 57,2			80	13 21,2	Mean ....10 59,26		
100	45 07,2				100	14 27,2			
120	46 02,8	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>275,85 sec.</u>			120	15 32,8	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>329,63 sec.</u>		
140	46 57,6				140	16 38,8			
160	47 52,8				160	17 44,8			
180	48 47,6				180	18 50,4			
200	49 42,8								
220	50 38								
240	51 32,4								
EXP. 3. NEEDLE A. Hour 3½ P.M.					EXP. 4. NEEDLE B. Hour 3 P.M.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> . in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	200 Vib <sup>ns</sup> . in
0	<sup>m</sup> <sup>s</sup> 40 43,2	300	<sup>m</sup> <sup>s</sup> 53 05,2	<sup>m</sup> <sup>s</sup> 12 22	0	<sup>m</sup> <sup>s</sup> 14 33,6	200	<sup>m</sup> <sup>s</sup> 26 06,8	<sup>m</sup> <sup>s</sup> 11 33,2
10	41 08,4	310	53 30	12 21,6	10	15 08,8	210	26 41,6	11 32,8
20	41 33,2	320	53 54,8	12 21,6	20	15 43,6	220	27 16	11 32,4
30	41 58,4	330	54 19,2	12 20,8	30	16 18,4	230	27 50	11 31,6
40	42 23,2	340	54 44	12 20,8	40	16 53,2	240	28 24,4	11 31,2
50	42 48	350	55 08,4	12 20,4	50	17 28	250	28 59,2	11 31,2
60	43 12,8	360	55 33,2	12 20,4	60	18 02,8	260	29 33,6	11 30,8
80	44 02,8	Mean ....12 21,09			80	19 12	Mean ....11 31,89		
100	44 52				100	20 21,2			
120	45 41,6	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>247,03 sec.</u>			120	21 30,4	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>345,94 sec.</u>		
140	46 31,2				140	22 39,6			
160	47 20,4				160	23 48,8			
180	48 09,6				180	24 58,4			
200	48 59,2								
220	49 48,4								
240	50 37,6								
260	51 26,8								
280	52 16								

In the grounds of Shernfold Park, Frant, Sussex : January 15th, 1827.

Observer, Captain SABINE. Therm. 38°. Chron. MOLYNEUX 407. Rate, Mean Time.

EXP. 5. NEEDLE VIII. Hour 2½ P.M.					EXP. 6. NEEDLE X. Hour 1½ P.M.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> . in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> . in
0	<sup>m s</sup> 31 13,6	300	<sup>m s</sup> 44 58	<sup>m s</sup> 13 44,4	0	<sup>m s</sup> 43 28,8	300	<sup>m s</sup> 59 54	<sup>m s</sup> 16 25,2
10	31 41,6	310	45 25,2	13 43,6	10	44 02	310	00 26,4	16 24,4
20	32 09,2	320	45 52,6	13 43,4	20	44 35,2	320	00 59,6	16 24,4
30	32 37,2	330	46 20	13 42,8	30	45 08,4	330	01 32	16 23,6
40	33 05,2	340	46 47,6	13 42,4	40	45 41,2	340	02 04,4	16 23,2
50	33 32,2	350	47 14,2	13 42	50	46 14,4	350	02 37,2	16 22,8
60	34 00,8	360	47 42,8	13 42	60	46 47,2	360	03 10	16 22,8
80	34 55,2	Mean .... 13 42,94			80	47 53,2	Mean .... 16 23,77		
100	35 50				100	48 58,8			
120	36 45,2	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>274,31 sec.</u>			120	50 04,4	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>327,92 sec.</u>		
140	37 40,4				140	51 10			
160	38 35,2				160	52 15,2			
180	39 29,6				180	53 21,2			
200	40 24,4				200	54 26,8			
220	41 19,6				220	55 32			
240	42 14,4				240	56 37,2			
260	43 09,2				260	57 42,8			
280	44 04				280	58 48,4			

EXP. 7. NEEDLE A. Hour 3½ P.M.					EXP. 8. NEEDLE B. Hour 4 P.M.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> . in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> . in
0	<sup>m s</sup> 30 06	300	<sup>m s</sup> 42 24	<sup>m s</sup> 12 18	0	<sup>m s</sup> 2 32,8	300	<sup>m s</sup> 19 47,6	<sup>m s</sup> 17 14,8
10	30 31,6	310	42 48,8	12 17,2	10	3 07,6	310	20 21,6	17 14
20	30 56	320	43 12,8	12 16,8	20	3 42,4	320	20 56	17 13,6
30	31 20,8	330	43 37,6	12 16,8	30	4 17,2	330	21 30,4	17 13,2
40	31 45,6	340	44 02	12 16,4	40	4 52	340	22 05,2	17 13,2
50	32 10,4	350	44 26,4	12 16	50	5 26,8	350	22 39,2	17 12,4
60	32 35,2	360	44 50,8	12 15,6	60	6 01,2	360	23 13,2	17 12
80	33 24,8	Mean .... 12 16,69			80	7 10,4	Mean .... 17 13,31		
100	34 14				100	8 19,2			
120	35 03,2	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>245,56 sec.</u>			120	9 28,4	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>344,44 sec.</u>		
140	35 52				140	10 37,2			
160	36 41,2				160	11 46,4			
180	37 30				180	12 55,2			
200	38 19,2				200	14 04,4			
220	39 08				220	15 12,8			
240	39 57,2				240	16 21,2			
260	40 46				260	17 30			
280	41 35,2				280	18 39,2			

In the Garden of the Observatory at Paris : January 30th, 1827.

Observer, Captain SABINE. Therm. 28°. Chron. MOLYNEUX, No. 407. Rate, Mean Time.

EXP. 9. NEEDLE VIII. Hour 11½.					EXP. 10. NEEDLE A. Hour Noon.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in
0	<sup>m</sup> 15 <sup>s</sup> 47,2	300	<sup>m</sup> 29 <sup>s</sup> 09,6	<sup>m</sup> 13 <sup>s</sup> 22,4	0	<sup>m</sup> 14 <sup>s</sup> 15,6	300	<sup>m</sup> 26 <sup>s</sup> 13,2	<sup>m</sup> 11 <sup>s</sup> 57,6
10	16 14	310	29 36,4	13 22,4	10	14 39,6	310	26 37,2	11 57,6
20	16 41,2	320	30 03,2	13 22	20	15 04	320	27 00,8	11 56,8
30	17 08	330	30 29,6	13 21,6	30	15 28	330	27 24,8	11 56,8
40	17 35,2	340	30 56	13 20,8	40	15 52	340	27 48,8	11 56,8
50	18 01,6	350	31 23,2	13 21,6	50	16 16	350	28 12,4	11 56,4
60	18 28,8	360	31 49,6	13 20,8	60	16 40,4	360	28 36,4	11 56
80	19 22,4	Mean .... 13 21,66			80	17 28,8	Mean .... 11 56,86		
100	20 16				100	18 16			
120	21 09,6	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>267,22 sec.</u>			120	19 03,6	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>238,95 sec.</u>		
140	22 03,2				140	19 51,6			
160	22 56,8				160	20 39,6			
180	23 50				180	21 27,6			
200	24 43,6				200	22 15,2			
220	25 37,2				220	23 02,8			
240	26 30,4				240	23 50,4			
260	27 23,2				260	24 38,4			
280	28 16,8				280	25 26			

EXP. 11. NEEDLE B. Hour 12 to 1 P.M.									
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in					
0	<sup>m</sup> 43 <sup>s</sup> 49,6	300	<sup>m</sup> 00 <sup>s</sup> 26,8	<sup>m</sup> 16 <sup>s</sup> 37,2					
10	44 23,6	310	01 00	16 36,4					
20	44 56,8	320	01 32,8	16 36					
30	45 30,4	330	02 05,6	16 35,2					
40	46 04	340	02 39,2	16 35,2					
50	46 37,2	350	03 12	16 34,8					
60	47 10,8	360	03 44,8	16 34					
80	48 17,6	Mean .... 16 35,54							
100	49 24								
120	50 30,4	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>331,85 sec.</u>							
140	51 36,8								
160	52 43,2								
180	53 49								
200	54 55,6								
220	56 02								
240	57 08								
260	58 14,4								
280	59 20,4								



Edinburgh: February 15th, 1827.

Observers, Captain BASIL HALL and Lieut. ROBERT CRAIGIE, R.N. Therm. 32°. Barom. 30,00.

Chron. gaining 1<sup>s</sup>,5 per diem.

EXP. 12. NEEDLE IV.				EXP. 13. NEEDLE IV.				EXP. 14. NEEDLE IV.			
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.
0	<sup>m</sup> 8 <sup>s</sup> 47,5	300	<sup>m</sup> 26 <sup>s</sup> 18,9	0	<sup>m</sup> 33 <sup>s</sup> 59,5	290	<sup>m</sup> 50 <sup>s</sup> 55,5	0	<sup>m</sup> 4 <sup>s</sup> 24	300	<sup>m</sup> 21 <sup>s</sup> 55,8
10	9 23,5	300 Vibrations in 17 <sup>m</sup> 31 <sup>s</sup> ,4. Whence the Mean Time of 100 Vibrations in Arcs between 30° and 5° <u>350,47 sec.</u>		10	34 35,5	290 Vibrations in 16 <sup>m</sup> 56 <sup>s</sup> . Whence the Mean Time of 100 Vibrations in Arcs between 30° and 5° <u>350,35 sec.</u>		20	5 35	300 Vibrations in 17 <sup>m</sup> 31 <sup>s</sup> ,8. Whence the Mean Time of 100 Vibrations in Arcs between 30° and 5° <u>350,6 sec.</u>	
20	9 58,5			20	35 11,0			40	6 45,5		
30	10 34			30	35 45,5			60	7 55,8		
40	11 09,5			40	36 20,7			80	9 06,5		
50	11 45,5			50	36 56,0			100	10 16,5		
60	12 19,5			70	38 06,5			120	11 26,5		
80	13 29,8			90	39 16,5			140	12 36,8		
100	14 59,7			110	40 26,5			160	13 46,8		
120	15 50,0			130	41 37,0			180	14 56,5		
140	16 59,5			150	42 46,5			200	16 06,5		
160	18 09,5			170	43 57,0			220	17 16,5		
180	19 19,5			190	45 06,5			240	18 26,5		
200	20 29,5	210	46 16,5	260	19 35,9						
220	21 39,5	230	47 26,0	280	20 46,0						
240	22 49,8	250	48 36,5								
260	23 59,2	270	49 46,0								
280	25 09,0										

EXP. 15. NEEDLE XI.					EXP. 16. NEEDLE XI.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in
0	<sup>m</sup> 47 <sup>s</sup> 31,0	300	<sup>m</sup> 63 <sup>s</sup> 26	<sup>m</sup> 16 <sup>s</sup> 05	0	<sup>m</sup> 16 <sup>s</sup> 52,5	300	<sup>m</sup> 32 <sup>s</sup> 57	<sup>m</sup> 16 <sup>s</sup> 04,5
10	48 03,5	310	64 08	16 04,5	10	17 25,0	310	33 29	16 04
20	48 36,0	320	64 40	16 04	20	17 57,5	320	34 00,2	16 02,7
30	49 08,5	330	65 12	16 03,5	30	18 30,0	330	34 33	16 03
40	49 41,0	340	65 44	16 03	40	19 02,5	340	35 04,8	16 02,3
50	50 13,5	350	66 16	16 02,5	50	19 35,0	350	35 37,0	16 02
60	50 45,5	360	66 47,5	16 02	60	20 07,3	360	36 09,0	16 01,7
80	51 50,2	Mean .... 16 03,5			80	21 11,7	Mean .... 16 02,9		
100	52 54,8				100	22 16			
120	53 58,8				120	23 20			
140	55 03,5				140	24 24,5			
160	56 07,5	Whence the Mean Time of 100 Vibrations in Arcs between 30° and 5° <u>321,17 sec.</u>			160	25 29	Whence the Mean Time of 100 Vibrations in Arcs between 30° and 5° <u>320,97 sec.</u>		
180	57 12,0				180	26 33			
200	58 16,2				200	27 37			
220	59 20,0				220	28 41,2			
240	60 24,0				240	29 45			
260	61 28,0				260	30 49			
280	61 32,0				280	31 53,2			

In the Garden of the Observatory at Paris : March 14th, 1827.

Observers, Captain SABINE and Mr. RITCHIE. Therm. 56°. Chron. MOLYNEUX, No. 407.  
Rate, Mean Time.

EXP. 17. NEEDLE X. Hour 1 to 2 P.M.					EXP. 18. NEEDLE XI. Hour 2 to 3 P.M.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in
0	<sup>m</sup> 31 <sup>s</sup> 13,6	300	<sup>m</sup> 47 <sup>s</sup> 12,4	<sup>m</sup> 15 <sup>s</sup> 58,8	0	<sup>m</sup> 59 <sup>s</sup> 17,2	300	<sup>m</sup> 14 <sup>s</sup> 31,2	<sup>m</sup> 15 <sup>s</sup> 14
10	31 46	310	47 44	15 58	10	59 48	310	15 01,2	15 13,2
20	32 18,4	320	48 16	15 57,6	20	00 18,8	320	15 31,6	15 12,8
30	32 50,4	330	48 48	15 57,6	30	00 49,6	330	16 01,6	15 12
40	33 22,4	340	49 19,6	15 57,2	40	01 20,4	340	16 32	15 11,6
50	33 54,8	350	49 51,6	15 56,8	50	01 50,8	350	17 02,4	15 11,6
60	34 26,8	360	50 23,2	15 56,4	60	02 21,2	360	17 32,8	15 11,6
80	35 30,8	Mean .... 15 57,5			80	03 22,4	Mean .... 15 12,4		
100	36 34,8				100	04 23,6			
120	37 38,8	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>319,17 sec.</u>			120	05 24,8	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>304,13 sec.</u>		
140	38 42,8				140	06 25,2			
160	39 46,4				160	07 26			
180	40 50				180	08 26,8			
200	41 54				200	09 27,6			
220	42 58				220	10 28,4			
240	44 01,6				240	11 28,8			
260	45 05,2				260	12 29,6			
280	46 08,8				280	13 30,4			
EXP. 19. NEEDLE A. Hour 2 to 3 P.M.					EXP. 20. NEEDLE B. Hour 3 P.M.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in
0	<sup>m</sup> 26 <sup>s</sup> 54	300	<sup>m</sup> 38 <sup>s</sup> 57,2	<sup>m</sup> 12 <sup>s</sup> 03,2	0	<sup>m</sup> 51 <sup>s</sup> 52	300	<sup>m</sup> 08 <sup>s</sup> 45,2	<sup>m</sup> 16 <sup>s</sup> 53,2
10	27 18,2	310	39 21,2	12 03	10	52 26	310	09 18,4	16 52,4
20	27 42,8	320	39 45,2	12 02,4	20	53 00,6	320	09 52,4	16 51,8
30	28 07,2	330	40 09,2	12 02	30	53 34,4	330	10 26	16 51,6
40	28 31,2	340	40 33,2	12 02	40	54 08,4	340	10 59,6	16 51,2
50	28 55,6	350	40 57,2	12 01,6	50	54 42,8	350	11 33,6	16 50,8
60	29 20	360	41 21,2	12 01,2	60	55 16,4	360	12 06,8	16 50,4
80	30 08,4	Mean .... 12 02,2			80	56 24	Mean .... 16 51,63		
100	30 56,8				100	57 31,6			
120	31 44,8	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>240,73 sec.</u>			120	58 39,6	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>337,21 sec.</u>		
140	32 32,8				140	59 46,8			
160	33 21,2				160	00 54			
180	34 09,2				180	02 01,6			
200	34 57,2				200	03 08,8			
220	35 45,2				220	04 16			
240	36 33,2				240	05 23,2			
260	37 21,2				260	06 30,8			
280	38 09,2				280	07 37,6			

In the Garden of the Horticultural Society, at Chiswick, near London :  
April 23d, 1827.

Observer, Captain CHAPMAN, R.A. Therm. 40°.

EXP. 21. NEEDLE IV. Hour 1 P.M.					EXP. 22. NEEDLE VIII. Hour 2 P.M.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in
0	<sup>m</sup> 27 <sup>s</sup> 32	300	<sup>m</sup> 44 <sup>s</sup> 37	<sup>m</sup> 17 <sup>s</sup> 05	0	<sup>m</sup> 7 <sup>s</sup> 32	300	<sup>m</sup> 21 <sup>s</sup> 21	<sup>m</sup> 13 <sup>s</sup> 49
10	28 06	310	45 11	17 05	10	8 00	310	21 49	13 49
20	28 40	320	45 45	17 05	20	8 27	320	22 16	13 49
30	29 15	330	46 20	17 05	30	8 55	330	22 45	13 50
40	29 49	340	46 54,5	17 05,5	40	9 23	340	23 13	13 50
50	30 23	350	47 28	17 05	50	9 51	350	23 40	13 49
60	30 57	360	48 02	17 05	60	10 18	Mean ....13 49,33		
80	32 07	Mean ....17 05,07			80	11 14			
100	33 15				100	12 09	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>276,44 sec.</u>		
120	34 23,5	120	13 04						
140	35 31	140	14 00						
160	36 39	160	14 56						
180	37 49	180	15 51						
200	38 57	200	16 46						
220	40 05	220	17 41,5						
240	41 13	240	18 36						
260	42 21	260	19 32						
280	43 29,5	280	20 27						

EXP. 23. NEEDLE X. Hour 2 to 3 P.M.					EXP. 24. NEEDLE XI. Hour 3 P.M.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in
0	<sup>m</sup> 38 <sup>s</sup> 26	300	<sup>m</sup> 54 <sup>s</sup> 59	<sup>m</sup> 16 <sup>s</sup> 33	0	<sup>m</sup> 4 <sup>s</sup> 09	300	<sup>m</sup> 19 <sup>s</sup> 51	<sup>m</sup> 15 <sup>s</sup> 42
10	38 58	310	55 32	16 34	10	4 40	310	20 22	15 42
20	39 32,5	320	56 05	16 32,5	20	5 11,5	320	20 54	15 42,5
30	40 05	330	56 38	16 33	30	5 44	330	21 26	15 42
40	40 39	340	57 11	16 32	40	6 15	340	21 57	15 42
50	41 11,5	350	57 44	16 32,5	50	6 47	350	22 29	15 42
60	41 46	360	58 17	16 31	60	7 18	360	22 59	15 41
80	42 52,5	Mean ....16 32,57			80	8 21	Mean ....15 41,93		
100	43 58				100	9 24			
120	45 05	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>330,86 sec.</u>			120	10 27	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>313,98 sec.</u>		
140	46 10,5				140	11 30,5			
160	47 17				160	12 33			
180	48 23				180	13 35			
200	49 29,5				200	14 38			
220	50 35,5				220	15 40,5			
240	51 42				240	16 44			
260	52 48				260	17 46			
280	53 53,5				280	18 49,5			

## In the Garden of the Observatory at Paris :

April 30th, 1827.

Observer, Captain SABINE. Therm. 77°. Chron. MOLYNEUX No. 407. Rate, Mean Time.

EXP. 25. NEEDLE A. Hour 3½ P.M.					EXP. 26. NEEDLE B. Hour 3 P.M.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in
0	<sup>m</sup> 33 <sup>s</sup> 29,2	300	<sup>m</sup> 45 <sup>s</sup> 33,6	<sup>m</sup> 12 <sup>s</sup> 04,4	0	<sup>m</sup> 1 <sup>s</sup> 41,6	300	<sup>m</sup> 18 <sup>s</sup> 37,2	<sup>m</sup> 16 <sup>s</sup> 55,6
10	33 53,6	310	45 58	12 04,4	10	2 16	310	19 41,2	16 55,2
20	34 18	320	46 22	12 04	20	2 50,4	320	19 45,2	16 54,8
30	34 42,8	330	46 46	12 03,2	30	3 24,8	330	20 18,8	16 54
40	35 07,2	340	47 10,4	12 03,2	40	3 58,8	340	20 52,4	16 53,6
50	35 31,2	350	47 34,4	12 03,2	50	4 33,2	350	21 26,0	16 52,8
60	35 55,6	360	47 58,4	12 02,8	60	5 07,2	360	22 00,4	16 52,2
120	38 20,4	Mean .... 12 03,6			100	7 22,8	Mean .... 16 54,03		
180	40 44,8				140	9 37,6			
240	43 09,2	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>241,2 sec.</u>			180	11 52,8	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>338,01 sec.</u>		
					220	14 07,6			
					280	17 30			

EXP. 27. NEEDLE XI. Hour 5 P.M.					EXP. 28. NEEDLE VIII. Hour 5½ P.M.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	350 Vib <sup>ns</sup> in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in
0	<sup>m</sup> 58 <sup>s</sup> 43,2	350	<sup>m</sup> 16 <sup>s</sup> 31,2	<sup>m</sup> 17 <sup>s</sup> 48	0	<sup>m</sup> 31 <sup>s</sup> 21,2	300	<sup>m</sup> 44 <sup>s</sup> 48,4	<sup>m</sup> 13 <sup>s</sup> 27,2
10	59 14,4	360	17 01,6	17 47,2	10	31 48	310	45 15,2	13 27,2
20	59 45,2	370	17 32	17 46,8	20	32 15,6	320	45 42	13 26,4
30	00 16	380	18 02,4	17 46,4	30	32 42,8	330	46 09,2	13 26,4
40	00 46,8	390	18 32,8	17 46	40	33 10	340	46 35,6	13 25,6
50	01 17,2	400	19 03,2	17 46	50	33 36,8	350	47 02,4	13 25,6
60	01 48	410	19 33,6	17 45,6	60	34 04	360	47 29,6	13 25,6
120	04 51,2	Mean .... 17 46,57			80	34 58	Mean .... 13 26,286		
180	07 54,4				100	35 51,6			
200	08 55,2	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>304,734 sec.</u>			120	36 45,2	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>268,76 sec.</u>		
220	09 56				140	37 39,3			
240	10 57,2				160	38 32,8			
260	11 58				180	39 26,4			
280	12 58,8				200	— —			
300	14 00				220	41 13,6			
320	15 00,8				240	42 07			
340	16 01,2				260	43 01,2			
					280	43 54,4			

In the Garden of the Observatory at Paris : May 10th, 1827.

Observer, Captain SABINE. Therm. 62°. Chron. MOLYNEUX No. 407. Rate, Mean Time.

EXP. 29. NEEDLE X. Hour 5 P.M.					EXP. 30. NEEDLE IV. Hour 5½ P.M.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in
0	<sup>m</sup> 10 <sup>s</sup> 52,4	300	<sup>m</sup> 26 <sup>s</sup> 55,2	<sup>m</sup> 16 <sup>s</sup> 02,8	0	<sup>m</sup> 39 <sup>s</sup> 57,2	300	<sup>m</sup> 56 <sup>s</sup> 32	<sup>m</sup> 16 <sup>s</sup> 34,8
10	11 25,2	310	27 27,2	16 02	10	40 31,2	310	57 04,8	16 33,6
20	11 57,6	320	27 59,2	16 01,6	20	41 04,4	320	57 38	16 33,6
30	12 30	330	28 30,8	16 00,8	30	41 38	330	58 11,2	16 33,2
40	13 02,4	340	29 02,8	16 00,4	40	42 11,2	340	58 44,4	16 33,2
50	13 34,4	350	29 34,8	16 00,4	50	42 44,4	350	59 17,2	16 32,8
60	14 06,8	360	30 06,8	16 00	60	43 18	360	59 50,4	16 32,4
80	15 11,2	Mean .... 16 01,14			80	44 25,2	Mean .... 16 33,37		
100	16 15,2				100	45 31,2			
120	17 19,2				120	46 37,2			
140	18 23,2				140	47 43,6			
160	19 27,2	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>320,38 sec.</u>			160	48 49,6	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>331,12 sec.</u>		
180	20 31,6				180	49 56			
200	21 35,6				200	51 02,4			
220	22 39,6				220	52 08			
240	23 43,6	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>331,12 sec.</u>			240	53 14			
260	24 47,2				260	54 20			
280	25 51,2				280	55 26			

In the Garden of the Horticultural Society at Chiswick : June 11th, 1827.

Observer, Captain SABINE. Therm. 69°. Chron. MOLYNEUX No. 407. Rate, Mean Time nearly.

EXP. 31. NEEDLE IV. Hour 3½ P.M.					EXP. 32. NEEDLE VIII. Hour 1½ P.M.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in
0	<sup>m</sup> 45 <sup>s</sup> 04,6	300	<sup>m</sup> 62 <sup>s</sup> 15,2	<sup>m</sup> 17 <sup>s</sup> 11,6	0	<sup>m</sup> 44 <sup>s</sup> 43,2	300	<sup>m</sup> 58 <sup>s</sup> 38	<sup>m</sup> 13 <sup>s</sup> 54,8
10	45 39,6	310	62 49,6	17 10	10	45 11,6	310	59 06	13 54,4
20	46 14	320	63 23,6	17 09,6	20	45 39,6	320	59 34,4	13 54,8
30	46 48,4	330	63 57,6	17 09,2	30	46 07,6	330	60 01,6	13 54
40	47 23,4	340	64 32	17 08,6	40	46 35,6	340	60 29,6	13 54
50	47 57,6	350	65 06,8	17 09,2	50	47 03,6	350	60 56,8	13 53,2
60	48 32	360	65 41,2	17 09,2	60	47 31,6	360	61 24,8	13 53,2
80	49 41,2	Mean .... 17 09,63			80	48 27,6	Mean .... 13 54,06		
100	50 50				100	— —			
120	— —				120	50 18,8			
140	53 07,6				140	51 14,4			
160	— —	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>343,21 sec.</u>			160	52 10,4	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>278,02 sec.</u>		
180	55 24,8				180	53 05,6			
200	56 33,2				200	54 01,2			
220	57 41,6				220	54 56,8			
240	58 50	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>278,02 sec.</u>			240	55 52,4			
260	59 58,4				260	56 48			
280	61 05,6				280	57 43,2			

In the Garden of the Horticultural Society at Chiswick, near London :  
June 11th, 1827.

Observer, Captain SABINE. Therm. 69°. Chron. MOLYNEUX No. 407. Rate, Mean Time nearly.

EXP. 33. NEEDLE XI. Hour $3\frac{1}{2}$ P.M.					EXP. 34. NEEDLE A. Hour 4 P.M.				
Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in	Vib <sup>ns</sup> .	Time.	Vib <sup>ns</sup> .	Time.	300 Vib <sup>ns</sup> in
0	m s 21 00,4	300	m s 36 48	m s 15 47,6	0	m s 48 57,2	300	m s 01 28,8	m s 12 31,6
10	21 32,4	310	37 19,2	15 46,8	10	49 22,4	310	01 53,6	12 31,2
20	22 04,4	320	37 50,8	15 46,4	20	49 48	320	02 18,4	12 30,4
30	22 36	330	38 22,4	15 46,4	30	49 13,2	330	02 43,2	12 30
40	23 08	340	38 53,6	15 45,6	40	50 38,8	340	03 08,4	12 29,6
50	23 39,6	350	39 24,8	15 45,2	50	51 03,6	350	03 43,2	12 29,6
60	24 11,2	360	39 56	15 44,8	60	51 29,2	360	03 58,4	12 29,2
80	25 14,8	Mean . . . . 15 46,11			80	52 19,2	Mean . . . . 12 30,23		
100	26 18				100	53 09,2			
120	27 21	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>315,37 sec.</u>			120	53 59,2	Whence the Mean Time of 100 Vibrations between the Arcs of 30° and 5° <u>250,07 sec.</u>		
140	28 24,4				140	54 49,2			
160	29 27,6				160	55 39,2			
180	30 30,4				180	56 29,2			
200	31 33,2				200	57 18,8			
220	32 36,4				220	58 08,8			
240	33 39,6				240	58 58,8			
260	34 42,4				260	59 48,8			
280	35 45,2				280	00 38,8			